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Description

Electronic circuit arrangement for generating a transmit frequency

The invention relates to an electronic circuit arrangement for generating a transmit frequency for a transceiver.

The inventors are familiar with similar circuit arrangements from the prior art for generating corresponding transmit frequencies in a TDMA radio system (for example DECT, GSM, PHS). The abbreviation TDMA stands for "Time Division Multiple Access". Such an arrangement is composed of an oscillator for generating frequencies, a transmit amplifier, a receiver and a control device which determines the chronological sequence of alternating transmit and receive states. In general, the oscillator frequency for setting the transmission channel via the control device using a PLL (phase locked loop) is set before the switching on of the transmitter since, for technical reasons, a certain setting time is required for this process. The invention relates to the case of transmission in such a TDMA system whose arrangement is illustrated schematically in figure 1.

The problem of such a simple circuit arrangement is that the generation of frequencies is disrupted at the moment of the switching on of the transmit amplifier owing to the load change in the amplifier or due to feedback. As a result, an undesired frequency jump is generated. Such a load change occurs, for example, during the switching on of the transmit amplifier as a result of the change in its input impedance. An effect on the generation of frequencies can arise, for example, owing to irradiation by the antenna, or due to other coupling parts between the transmit output stage and the

generation of frequencies, for example due to the supply voltage.

In particular in TDMA systems which, for costs reasons, operate with a slow PLL control loop, or open the control loop for the duration of the modulation, this effect is a large problem for the implementation because the frequency jump can no longer be corrected by the PLL circuit. An example of this is the open-loop modulation of a DECT system.

The abovementioned problem is tackled by means of various circuit arrangement known to the inventors. For example, there is a possibility of bringing about a reduction in the load change which is visible for the generation of frequencies by inserting damping elements and isolating stages between the frequency generating means and the transmit amplifier. In addition, additional shielding of the frequency generating means in the form of a Faraday cage can ensure that the irradiation is reduced. Furthermore, additional blocking against electromagnetic irradiation, for example by means of specially shaped plugs, can be provided on the lines which lead into the shield. An example of such a known circuit device is shown in figure 2.

It is also known that the insertion of frequency multiplication stages or divider stages in the frequency generating means prevents the feedback and thus the influence on the frequency generating means. Here, an oscillator oscillates at a harmonic or subharmonic of the desired frequency, as a result of which both a low load dependence and a lower sensitivity to the irradiation of undesired frequencies is produced in accordance with the degree of multiplication or division. This

circuit is illustrated schematically in figure 3.

Finally, the relatively costly use of a transmission mixing concept, such as is illustrated schematically in figure 4, for solving the abovementioned problem is known to the inventors.

In this transmission mixing concept, the frequencies of two oscillators are mixed in a mixer stage and the desired frequency filtered out from the mixing products. Because the oscillators have a nonharmonic relationship with the desired frequency, there is a resulting high degree of immunity to the load changes and effects. As a result, the requirements made of the shielding, the blocking and the isolation stages are reduced considerably in comparison with the known solutions from figures 2 and 3.

The greatest disadvantage of this transmission mixing concept is the large degree of technical expenditure which it requires because a transmission mixer stage, an oscillator including a PLL circuit for frequency stabilization and a band filter are additionally required. The additionally required electronic components alone result in a considerable cost disadvantage in comparison with the two preceding solutions.

A further disadvantage of this more costly transmission mixing concept is that the overall size of such a circuit arrangement is too large owing to the number of additional electronic components.

In this transmission mixing concept, it proves particularly problematic to achieve a high degree of integration because given the current state of the art the filters and oscillators or oscillator coils are very difficult to accommodate in integrated circuits,

or

require a very large chip area. In addition, it is frequently impossible to integrate to a sufficient degree the capacitors and resistors which are required for the PLL so that they have to be arranged as external components.

Because a total of two oscillators for frequency stabilization, two PLLs, including two external loop filters, are necessary in the known transmission mixing concept, and in particular oscillators with a low frequency require a particularly large chip area or have poor properties with respect to phase noise, this transmission mixing concept proves relatively unsuitable for a high integration density.

The object of the invention is therefore to disclose an electronic circuit arrangement for generating a transmission frequency which electronic circuit arrangement on the one hand offers the favorable technical requirements of the transmission mixing concept and on the other hand permits a high integration density of the circuit to be achieved, and thus makes cost-effective manufacture possible.

The object is achieved by means of the features of claim 1.

Accordingly, an electronic circuit arrangement is proposed for generating a transmit frequency f_s for a transceiver, which circuit contains the following components: a controllable oscillator for generating an oscillator frequency f_{osz}, a divider by a factor N and a mixer stage with a subsequent band filter, the components being connected to one another in such a way that the oscillator frequency f_{osz} and an oscillator frequency f_{osz}/N divided by the factor N are fed to the mixer as input signals and output by it as transmit frequency f_s.

A significant advantage of this arrangement is that a lower phase noise is produced with the circuit arrangement according to the invention than would be achievable with the two oscillators of the known transmission mixing concept because only a single oscillator can contribute to the phase noise.

A simplification of the structure of the circuit is achieved by virtue of the fact that, instead of the mixer stage with subsequent band filter, a single-sideband mixer (= Image Reject Mixer) is used. Single-sideband mixers are available as ready-made components and can be integrated into the circuit structure in a compact fashion.

A further advantageous refinement of the electronic circuit arrangement according to the invention can consist in using a PLL circuit for stabilization, to which PLL circuit a reference frequency, and either the oscillator frequency or the output frequency of the band filter or if appropriate of the single-sideband mixer, are fed as input signals.

Furthermore, it may be advantageous if the factor N of the divider supplies a multiple of the number of the 2 and/or is greater than 1 and supplies two output signals which are phase-shifted with respect to one another by 90°.

The desired phase shift by 90° can be achieved by the phase shifting of part of the signal by 90° and maintenance of the original phase for the remaining part of the signal, or by phase shifting both parts of the signal by +45° and -45°, respectively. In both cases, a phase difference of 90° remains.

A further advantageous refinement of the electronic circuit arrangement according to the invention can consist in the fact that a control device is additionally provided which, at the

time of the switching on of a transmit output stage connected to the output of the single-sideband mixer, superimposes on an oscillator control signal a data signal for generating a frequency modulation. Such a control device is used, for example, in what is referred to as TDMA systems.

In respect of optimal integration and simple implementation of the circuit it is also advantageous to implement the control device using an ASIC component.

Another advantageous refinement of the circuit arrangement provides for the control device to activate two switches alternately, which enables a connection of the oscillator control input either to a data modulator or for the purposes of channel setting to the PLL.

Furthermore, an alternative refinement to the electronic circuit arrangement according to the invention can consist in the fact that a superimposition receiver is provided which obtains a superimposition frequency directly from the oscillator frequency f_{osz}, and that a changeover device is provided which in the case of transmission feeds the single-sideband mixer output frequency and in the case of reception feeds the oscillator frequency to the PLL.

The oscillator can advantageously operate in a voltage-controlled or current-controlled fashion, for example, and if appropriate a reference frequency can also be fed externally.

Of course, the abovementioned features of the invention which are to be explained can be used not only in the respective specified combination but also in other combinations or alone without departing from the scope of the invention.

Further features and advantages of the invention emerge from the following description of preferred exemplary embodiments with reference to the drawings.

The invention will be explained below in more detail with reference to the drawings, in which, in particular:

Figs. 1-4: show circuit arrangements from the prior art;

Fig. 5: shows a circuit arrangement with mixer and subsequent band filter;

Fig. 6: shows a circuit arrangement with single-sideband mixer;

Figs. 7-10: show circuit arrangements with different modulator arrangements;

Figure 11: shows a circuit arrangement with superhet receiver and use of the oscillator at the receiver end;

Figure 12: shows a circuit arrangement with single-sideband mixer and superhet receiver with a transmit/receive band filter;

Figure 13: shows a circuit arrangement with single-sideband mixer and TDMA control device.

Figure 1 shows a known circuit arrangement for a TDMA radio system with an oscillator 2 and a PLL circuit 1 for generating a frequency which is as stable as possible, a TDMA controller 3 of a transmitting amplifier 4 and an antenna 5.

In this circuit arrangement, at the moment of the switching on of the transmitting amplifier 4, the generation of frequencies is disrupted owing to a load change and/or effects - indicated by the arrows 6 and 7 - and an undesired frequency jump is produced. The load change occurs during the switching on of the transmitting amplifier 4 as a result of the change in its input impedance.

Effects on the frequency generating means are produced as a result of the irradiation by the antenna 5, or by other coupling paths (not illustrated here) between the transmit output stage and the frequency generating means. An example of this are the supply voltage feeder lines.

Figure 2 shows a known circuit for avoiding the frequency jump. The circuit contains, in addition to the components illustrated in figure 1, the damping elements 8, 9 and one or more further amplifier stages for reducing the load change which is visible to the frequency generating means. Additional shielding (Faraday Cage) 12 of the frequency generating means for reducing irradiation is also illustrated. Furthermore, there is usually high frequency blocking means (not illustrated here) of the lines leading into the shielding.

Figure 3 shows a further known variant of a frequency generating circuit with a frequency multiplication stage or divider stage 13. In this example, the oscillator 2 oscillates at a harmonic or subharmonic of the desired transmit frequency, as a result of which both a lower load dependence and a lower sensitivity to electromagnetic irradiation arises in accordance with the degree of multiplication or division.

The best known circuit with the most effective suppression of feedback and frequency jumps during the switching on of the transmitting amplifier is illustrated in figure 4. This figure 4 shows a circuit arrangement for generating a transmit frequency using a transmission mixing concept. Here, the frequency of the first oscillator 2 and to the first PLL circuit 1, and the second frequency of the second oscillator 2 and to the second PLL circuit 15 is mixed in

the mixer stage 16, and the desired frequency is filtered out of the mixing products by means of the band filter 17.

If the frequencies of the oscillators 2 and 14 are selected such that they have a nonharmonic relationship with the desired frequency, there is a resulting high degree of immunity to load changes, that is to say during the switching on of the transmitting amplifier, and to its effects. As a result, the requirements made of the shielding, blocking and isolating stages are reduced considerably in comparison with the circuit arrangements from figures 2 and 3. The expenditure on circuitry is disadvantageous because a mixer stage 16, an oscillator 14 and a PLL circuit 15 for frequency stabilization and a band filter 17 are additionally required.

Figure 5 shows a simple circuit arrangement according to the invention for a radio system in which a high degree of cost savings can be achieved by a good degree of integration. The transmission mixing concept was selected as a starting point, but the second oscillator was dispensed with.

The second arrangement is composed, at the input end, of a single oscillator 2 which is stabilized by means of a PLL circuit 1. A summing stage 18, by means of which an FM modulation signal 26 can be supplied, is arranged between the oscillator 2 and the PLL circuit 1. The frequency f_{osz} of the oscillator 2 is fed to a frequency divider 19, and the frequency f_{osz}/N is generated. Both frequencies f_{osz} and f_{osz}/N are then fed to a mixer 32 in order to form the transmit frequency f_s. In the subsequent band filter 22, the undesired secondary frequencies which have also been produced are filtered out and the filtered frequency is conducted to the amplifier output stage 4. Either the oscillator frequency f_{osz} can be fed back to the PLL circuit 1 via the line 34, or

the transmit frequency f_s can be fed back to the PLL circuit 1 from the output of the band filter 33.

The desired transmit frequency f_s is thus obtained by:

$$f_s = f_{osz} \pm \left(\frac{f_{osz}}{N}\right) = f_{osz} * \left(1 \pm \frac{1}{N}\right)$$

where fs = transmit frequency, f_{osz} = oscillator frequency, N = divider factor

As is apparent from the mathematical relationship, a nonintegral relationship results between the transmit frequency f_s and the oscillator frequency f_{osz}, which promises a good degree of immunity to effects. The selection of the signs in the formula is determined by the connection of the single-sideband mixer. There is the freedom to allow the oscillator to oscillate either below or above the desired frequency. Basically, the oscillator frequency f_{osz} can also be selected in such a way that the oscillator frequency f_{osz} fulfils the criterion of the best phase noise (best quality of the coil) given the equipment.

In addition to the circuit arrangement according to the invention for generating the transmit frequency, a TDMA controller 31, known per se, for which the circuit arrangement for generating frequencies according to the invention is particularly suitable is also illustrated in figure 5.

Figure 6 shows a further development of the circuit arrangement according to the invention from figure 5.

In this further development, a single-sideband mixer (= Image Reject Mixer) 20 was used instead of the mixer 32 and the subsequent band filter 33. If the operating conditions require it, another filter element (not illustrated) for suppressing the harmonics of the divided signal can also be used downstream of the divider 19.

The single-sideband mixer 20 typically has a first phase shifter 21 for phase shifting and dividing the incoming oscillator frequency f_{osz} and a second phase shifter 22 for phase shifting the incoming divided oscillator frequency f_{osz}/N by 90° in each case. These frequencies which are each phase-shifted by 90° are mixed in the mixers 23 and 24, superimposed in the summing stage 25 and output as a desired transmit frequency f_s.

It is to be noted that the purpose of the phase shifting of 0° and 90° illustrated here can also be achieved by a phase shift by -45° and +45°.

The desired transmit frequency f_s is also obtained here and in all the further examples in accordance with the same formula to be described with respect to figure 5.

Since the frequency divider and single-sideband mixer can be integrated without difficulty with the contemporary technologies, this circuit arrangement leads to a considerable saving in chip area. Furthermore, there is a saving of a PLL with the external components of the loop filter connected thereto.

Another circuit arrangement according to the invention for generating a transmit frequency is illustrated in figure 7. The oscillator frequency f_{osz} is fed on the one hand to a divider 19 and on the other hand to a phase shifter 36. By using a factor N which can be divided by two, the phase shift of 90° required for the principle of single-sideband mixing can advantageously be generated easily and precisely, as a result of which there is better suppression of the undesired sideband from the mixing process.

The output signals which are shifted by 90° are obtained in a generally known way in that the last divider stage of a divider chain is a double design, one of the two divider stages being fed the input signal in inverted form.

Figure 8 shows a variant of the simple embodiment of the circuit arrangement according to the invention from figure 5 with a mixer 33 and downstream band filter 33. The difference with respect to figure 5 is that here a modulation signal 41 is emitted to a modulator 40 which is arranged between the divider 19 and mixer 32. This modulator 40 can be embodied, for example, as a vector modulator. The mixer 32 which is illustrated in simplified form contains in practice two individual mixers, each being responsible for one signal.

Such an embodiment has the advantage that any desired, even multivalued types of modulation can be generated with good frequency and/or phase stability.

The modulation signal 4 which is supplied can, for example, be the IQ baseband, generated by a digital signal processor, of a GMSK, N-PSK or quadrature amplitude modulation.

Another modification of the circuit arrangement according to the invention is illustrated in figure 9. This corresponds essentially to figure 5, but here, in order to generate and modulate the transmit frequency, two frequencies $f_{osz}(0°)$ and $f_{osz}(90°)$ which are phase-shifted by 90° and divided by N are fed to a mixer stage 39, which simultaneously operates as a modulator in that it mixes the data signals into a baseband conditioning means I and Q. The output signals are then conducted to the summing stage 25 and fed to the mixer 32. Here, the advantage arises from the precisely generated 0°/90° phase shift from the divider N which is required by the IQ modulator.

In the mixer 32, the transmit frequency f_s including secondary frequencies is in turn generated by mixing with the oscillator frequency f_{osz}, the secondary frequencies are largely filtered out during passage through the subsequent band filter 33 and the remaining transmit frequency f_s is conducted to the transmitting amplifier 4 and irradiated via the antenna 5. As in figure 5, the optional TDMA controller 31 is also illustrated.

A further possible way of transferring a modulation onto the transmit signal is illustrated in figure 10. The circuit arrangement also corresponds here to the simple design from figure 5, but a modulation is not superimposed on the oscillator frequency, but rather, instead of the band filter 33, a modulator 40, to which a modulation signal 41 is fed by a baseband, is arranged downstream of the mixer 32. This is therefore a "combination" of the design with an IQ modulator with which any desired types of modulation can be implemented, as illustrated in figures 8 and 9.

Figures 5 to 10 thus show a very wide variety of possibilities of modulating a transmit frequency f_s generated according to the invention by means of different types of modulation such as GMSK (= Gaussian minimum shift keying), nPSK (= n-multiple phase shift keying) or QAM (= quadrature amplitude modulation).

Figure 11 shows a further circuit arrangement which illustrates a combination of frequency generation with a superhet receiver and provides further advantages. The basic design of the circuit corresponds to the circuit arrangement from figure 6, but there is additionally a superimposition receiver 36 with integrated receive mixer 37 and the

additional changeover switch 38, which permits the same PLL step size in the transmitting and receiving modes.

In the receiving mode, the oscillator 2 generates the superimposition signal, while in the case of transmission the same oscillator 2 is used to generate the transmit frequency. The intermediate frequency in the case of reception is selected in such a way that it lies in the vicinity of the oscillator offset frequency in the case of transmission. The tuning range of the receiver is somewhat smaller in accordance with the offset between the transmit frequency and oscillator frequency, which however has hardly any effect in practice with relatively large divider factors. The coupling with the PLL is carried out by means of the changeover switch 38, downstream of the single-sideband mixer 20 in the case of transmission and directly by the oscillator 2 in the case of reception, in order to permit a uniform tuning step size of the PLL with the same reference frequency. It is advantageous here that only a single oscillator 2 is necessary for the transmitting mode and the receiving mode and at the same time good stability of the transmit frequency is achieved in the TDMA mode.

This circuit design shown is particularly suitable for DECT systems.

A disadvantage of the circuit arrangement according to the invention in comparison with an oscillator which operates at the limit frequency, namely the additional undesired mixing products of a real single-sideband mixer, can be reduced by adding a high-frequency filter, necessary in any case in the receiver, upstream of the transmit/receive changeover switch. In this case, the filter is used both for the transmit branch and for the receive branch.

Such a solution is illustrated by way of example in figure 12, which, apart from the transmitting amplifier 4, corresponds to the circuit arrangement from figure 6. The transmit/receive

changeover switch 28, which changes over between the transmit amplifier 4 and the receiver 30 (indicated by broken lines) is arranged subsequently. The aforementioned high-frequency filter 29 is connected between the antenna 5 and the transmit/receive changeover switch 28.

Finally, figure 13 also shows a circuit arrangement according to the invention with a single-sideband mixer 20 as is described in figure 6. In this case, the TDMA controller 31 however ensures that a data signal for generating a frequency modulation is superimposed on the oscillator control signal at the time of the switching on of the transmit output stage.

This is an arrangement such as is used, for example, in a DECT system with "open-loop modulation method". When the switch 32 is closed, the oscillator 2 is set to the desired channel by means of the PLL circuit 1 during a time slot which is not required for the transmitting/receiving mode. Just before the start of transmission, the switch 32 opens and the control variable which is acquired up to that point is stored in a storage element, not illustrated separately in the figure. A baseband signal for generating the DECT-GFSK (Gaussian frequency shift keying) modulation is superimposed by means of the switch 32 during the emission of the stored control variable. The necessary frequency stability is made possible during the emission by the arrangement according to the invention of the divider and mixer or single-sideband mixer. That is to say, high-frequency effects from the transmitter stage on the oscillator 2 do not bring about any frequency offset after the switching on of the transmitter.

In total, the circuit arrangement according to the invention therefore ensures that, on the one hand, the favorable technical requirements of the transmission mixing concept can be utilized

and, on the other hand, a high integration density of the circuit, and thus cost-effective manufacture are made possible.